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Windbreaks for Conservation

Contents

Cover photo: *Windbreaks provide a significant contribution for protecting the crops, structures, animals, and people on this Great Plains farm.*

Windbreaks for Conservation

Trees are nature's outdoor air conditioners. If hot summer winds and raw wintry blasts cause wind erosion or crop damage, windbreaks can reduce the hazard anywhere trees can be grown successfully.

Where natural protection is lacking, windbreaks of trees and shrubs protect homes and farmsteads from frigid storms and soil-blowing winds. Moreover, trees and shrubs add beauty and a sense of permanence to homes and communities. The returns in comfort and protection far outweigh the costs.

Conservation Value of Windbreaks

Windbreaks improve the quality of life on a farm or ranch or in a country home. People in many areas find windbreaks useful. Although windbreaks are found more often in the North and West than in the South and East, they are proving to be useful in every State—even in the Deep South. Farmers and ranchers in the United States have planted and benefited from them for the past 60 years and some cases longer. The country homeowner also appreciates the value of windbreaks. Windbreaks are useful in many ways including increased crop yields and improved sustainability of agricultural enterprises.

Windbreaks help control wind erosion, reduce the drying effects of wind on soil and plants, and help prevent the abrasive action rapidly moving soil particles have on young tender seedlings.

To lessen the problem of wind erosion in fields, windbreaks are needed in parts of the vast Great Plains; on the sandy and muck soils in the Great Lakes region; on sandy soils along the Atlantic and Gulf seaboards; and in the irrigated valleys of the Pacific Southwest and the Rio Grande, Colorado, and Columbia River basins.

During the winter, windbreaks trap snow that later melts. The melted snow provides moisture for growing plants in the spring and summer and also contributes to the supply of ground water. Furthermore, windbreaks provide homes for insect-eating birds. Upland game birds and other wildlife use them for cover, food, nesting, and travel lanes. Bees and other pollinating insects find protection on the leeward side of windbreaks.

Windbreaks make sprinkler irrigation more effective by protecting the spray against evaporation from shifting winds. As a result, pipelines do not have to be reset as often, and the water is distributed more uniformly.

A tree windbreak protects this farmstead from high winds, dust, and drifting snow.

Fields of sandy soils in North Dakota are stabilized by windbreaks and stripcropping.

Planted around country homes and farmsteads, windbreaks protect people, livestock, and yards from high winds, airborne dust, and drifting snow. They reduce health hazards caused by dusty air, help reduce noise from highways, machinery, or other sources, and can be used to screen out unsightly views. A well-planned windbreak will increase the livability of the home area immeasurably.

To reduce wind erosion

Fine soil particles, both organic and mineral, are easily moved by wind. Often the soil particles that blow from a field contain 10 to 20 times as much humus and phosphate as the heavier particles that stay on the field.

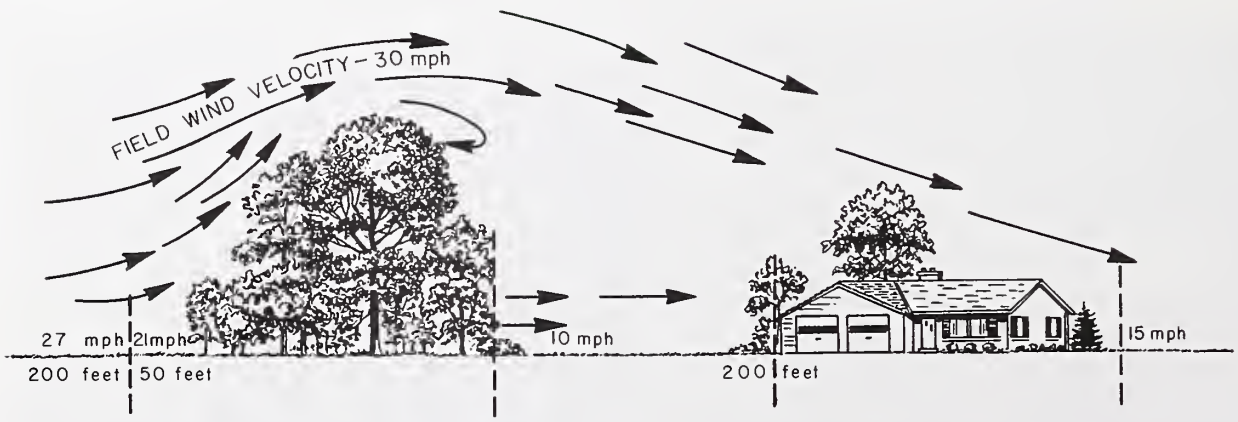
Soil particles do not ordinarily become airborne until wind velocity is about 13 miles per hour 1 foot above the ground. This is known as threshold velocity. Above threshold velocity the capacity of winds to carry soil is proportional to the cube of the wind velocity. Small reductions in wind velocity, therefore, cause a greater proportionate reduction in the rate of soil loss.

Soil from a large bare field is more likely to blow than soil from a small field. As the distance across bare soil increases, "avalanching" occurs which is the buildup in the amount of soil being moved by the wind. Windblown soil may fill irrigation and drainage ditches and pile up along fence rows and on roads. Blowing soil may even create highway driving hazards by limiting vision. Recent studies show that 90 percent of damage caused by wind erosion takes place offsite.

Wind erosion can be controlled in several ways. Having good plant cover, using conservation tillage practices that leave adequate crop residues, and using windbreaks to reduce the wind's velocity are among the ways to control wind erosion. Often a single measure is enough, but a combination of measures is needed where erosion hazards are high. A windbreak or a series of windbreaks is the backbone of a good wind-erosion control system.

Once windbreaks are well established, they protect fields all year. Measured in the direction the wind is blowing, windbreaks provide full protection to an area 10 times the height of the trees and give some protection as far out as 20 times the height of the trees.

A pattern of windbreaks protects soil and crops.



Windbreaks reduce wind currents: Part of the air current is diverted over the top of the trees and part of it filters through the trees. Farmstead, livestock, and wildlife windbreaks should be relatively dense and wide to give maximum protection close to the trees. Windbreaks for fields, orchards, and gardens need not be as wide and dense.

For human comfort

Your skin, normally at a temperature of 91.4 °F, loses heat quickly when exposed to wind. The stronger the wind, the greater the cooling effect.

U.S. Army research teams studied the effect of wind on human skin surface in Antarctica and other places. A single number—called the windchill index—gives the combined effect of wind and temperature. A 30-mile-per-hour (mph) wind at a temperature of 10 °F, for example, can cause the same heat loss from exposed skin as an equivalent temperature of minus 33 °F with no wind. A dense windbreak reduces a 30-mph wind to 10 to 15 mph. At 10 °F, this means a change in windchill index from minus 33 to about minus 13. Close to the windbreak, the windchill index would be around 7.

To protect homes in open country

Windbreaks of trees and shrubs can beautify your home and its surroundings and make it a more pleasant place to live. Evergreens break the drab monotony of winter; broadleaf (deciduous) trees and flowering shrubs add color for the rest of the year. Best of all, windbreaks protect the house and yard from freezing gusty winds, blowing soil, and drifting snow. In many parts of the country, cold winds cause more discomfort to humans and animals than any other climatic factor.

If wind is reduced, your home will be more comfortable and you will use at least 15 percent less home fuel. In addition, there will be less dust to clean up. Outside your home, you can design your windbreaks to control snowdrifting by proper placement and planting of trees and shrubs.

Shade trees, shrubbery, lawns, flowers, gardens, and family-size orchards are easier to establish and maintain if a windbreak shelters them.

Windbreaks make a delightful place for children to play. Some country homeowners increase the benefits from their windbreaks by using a part of them as a picnic area. Helpful suggestions can be found in the section dealing with the planning of windbreaks.

Wind	Windchill index for thermometer reading									
Velocity	50 °F	40 °F	30 °F	20 °F	10 °F	0 °F	-10 °F	-20 °F	-30 °F	-40 °F
Calm	50	40	30	20	10	0	-10	-20	-30	-40
5 mph	48	37	27	16	7	-6	-15	-26	-35	-47
10 mph	40	28	16	2	-9	-22	-31	-45	-58	-70
15 mph	36	22	11	-6	-18	-33	-45	-60	-70	-85
20 mph	32	18	3	-9	-24	-40	-52	-68	-81	-96
25 mph	30	16	0	-15	-29	-45	-58	-75	-89	-104
30 mph	28	13	-2	-18	-33	-49	-63	-78	-94	-109
35 mph	27	11	-4	-20	-35	-52	-67	-83	-98	-113
40 mph	26	10	-6	-22	-36	-54	-69	-87	-101	-116

Relative responsiveness of various crops to shelter

Crop	No. of Field-years	Weighted Mean Yield Increase (Percent)
Spring wheat	190	8
Winter wheat	131	23
Barley	30	25
Oats	48	6
Rye	39	19
Millet	18	44
Corn	209	12
Alfalfa	3	99
Hay (mixed grasses and legumes)	14	20

To protect crops

Many growers continue to recognize the crop yield benefits of protecting their crops from damaging winds. Worldwide studies show there isn't a crop grown that will not benefit from wind protection.

Yields on some crops may be lowered by gusty, hot winds. Strong winds blow crops to the ground before maturity, making them difficult to harvest. Research shows that plants will be affected when wind speeds exceed 7 mph.

A windbreak adds comfort and livability to homes in open country.

Moving soil particles and the whipping action of strong winds frequently damage the leaves of tender plants and twist or break their stems. This kind of damage makes replanting necessary. Research shows that abrasion can also spread fungi and bacterial organisms in sugar beets and some truck crops.

Field windbreaks can reduce some of the risks associated with farming wherever wind erosion and wind damage to crops are hazards. The use of windbreaks can increase the opportunities to farm more intensively and to grow crops that yield a higher income. Their use along with other conservation practices will increase the sustainability of an agricultural enterprise.

Windbreaks also modify the microclimate on the lee side of the barrier. They warm the soil and help crops mature earlier.

Protecting crops from damaging winds may help improve the quality of some row crops. Tomato growers in the Salinas Valley of California use annual sunflowers as windbreaks to maintain the grade level of their crops.

At Scottsbluff, Nebraska, irrigated sugar beets were planted between rows of slatted fence 4 feet high and 50 feet apart and between two-row corn windbreaks similarly spaced. Beets in check plots without shelter produced 21.0 tons per acre; those sheltered by the fence rows, 24.1 tons per acre; and those sheltered by the corn rows, 26.5 tons per acre.

Winter wheat yields increased 15 percent in fields protected by windbreaks in eastern Nebraska. The cost of windbreak establishment and the loss of wheat production in the area occupied by the trees were recovered in the form of increased yields at the end of 15 years. After the 15 years, annual revenues showed a net gain. Over the 50-year life of the windbreak, the producer realized an estimated total of $22,000 in extra net revenue for each 160 acres protected.

In South Dakota, 331 farmers were asked about their experiences with field windbreaks. Of these farmers, 274 reported increased crop yields in 1 or more of the 3 years studied. They credited the increased yields to the use of windbreaks. They estimated an increase of 5 to 9 bushels of corn per acre on the parts of the fields protected by windbreaks and similar increases in other crops.

In Ontario, Canada, researchers reported an increased yield of 20 percent in soybeans to a distance of 10 times the height of the windbreak on the leeward side.

With well designed windbreaks, many cotton farmers in the sandy soil of Texas and Oklahoma get cleaner, whiter cotton and less boll-shedding. Furthermore, the higher-grade cotton brings a better price, the lint is more nearly free of sand, and cotton-picking need not be delayed because of high winds.

To control wind erosion and protect crops, narrow (one or two rows) field windbreaks have been used for many years in the muck, peat, and sandy soils of the Corn Belt and the Northeast, the valleys of the Pacific Coast States, the Southwest, and other parts of the country.

In the Northern Plains, the added moisture from snowdrifts on the leeward side of windbreaks helps in the production of a good crop during dry seasons through improved spring moisture for germinating.

Crops differ in their responsiveness to shelter. Field and forage crops, such as winter wheat, barley, rye, millet, alfalfa, and hay (mixed grasses and legumes), are highly responsive to protection. Average yield increases for vegetable and specialty crops protected by

Crop yields often are lowest next to a tree windbreak. A common mistake is to observe only this area—the greatest gains are out a few more rods.

windbreaks range from 5 to 50 percent. Strawberries and other soft fruit show a big increase in yield and grade when protected from damaging winds.

In orchards, vineyards, and gardens

Orchards and vineyards need shelter against high winds, especially during pollination and when the fruit is ripening. In unprotected orchards, high winds can blow fruit off the trees, bruising and scarring it.

Citrus fruits are easily damaged by hot winds that dry the leaves and fruit. Orchards protected by windbreaks produce both higher yields and higher quality fruit. Data from Orange County, California, show the average return per acre from 20 citrus orchards having windbreak protection to be almost double that from 20 unprotected orchards.

Windbreaks assist maintenance activities in many ways. Behind a good windbreak, fruit trees can be sprayed, dusted, and pruned more easily. Honeybees and other pollinating insects are more effective when sheltered against winds. Windbreaks help reduce irrigation evaporation and protect clean-cultivated orchards from wind erosion. In the North, properly located windbreaks trap snow and add more moisture for fruit production. As with other crops, earlier crop maturity can be achieved when the crop is protected from cold winds.

Researchers know that winds in vineyards can slow plant growth. Depending on the variety of some grape species, this plant growth reduction may last for several days, and possibly could delay fruit ripening.

A windbreak of bluegum protects a young citrus orchard in California.

Vegetable gardens and small family orchards also benefit from properly designed windbreaks. In snow country many farmers plant their gardens and berry crops between a windbreak and buildings. The trapped snow provides additional moisture when it melts.

To protect livestock

Livestock do better when protected from wintry winds and snow. Windbreaks help to provide needed shelter by reducing wind velocity and trapping snow away from the containment area. The benefits include increased feed efficiency, greater weight gains, increased survival of newborns, improved animal health, increased milk production, and ultimately increased profits. In this bulletin, the section "Planning Windbreaks" has more information about livestock shelters.

Many ranchers are planting windbreaks to protect their cattle and sheep from blizzards and cold, driving rains.

A seven-year-old poplar windbreak protects a kiwi vineyard in California.

This properly designed windbreak will increase the quality and yield of the fruit from this orchard in Michigan.

This dense Nebraska windbreak protects cattle from snow and dangerous cold wind.

The red berries of a silver buffaloberry provide food for wildlife.

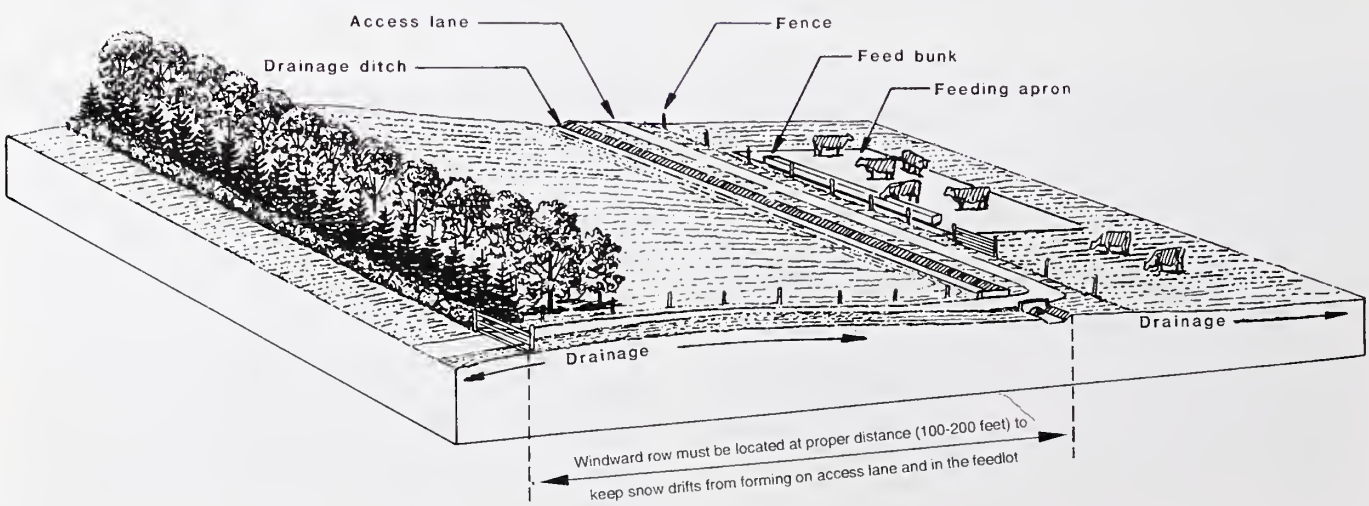
Kansas cattle producers indicate, that on average, calving success increases by two percent if cows are protected by a windbreak. Research at Purdue University found that energy requirements for cows in good condition increased 13 percent for each 10 degree drop in windchill temperature below 30 degrees.

Studies in Montana found that a herd of cattle protected by windbreaks gained an added 35 pounds per head during a mild winter and lost at least 10 pounds less during a severe winter.

For wildlife habitat

Windbreaks provide valuable cover and nesting areas for upland game and songbirds. In the summer, these windbreaks provide homes for insect-eating birds close to cropland . Biologists examined a half-mile field windbreak in Texas and found 25 occupied bird nests and a covey of sheltered quail. The biologists estimated this bird population would consume about 260 pounds of insects during the year. In winter when all other food is blanketed with snow, seeds and fruits of the tree and shrub windbreaks provide food for nonmigratory birds.

To be of greatest value to wildlife, a windbreak should include at least one row of dense, low-growing shrubs or evergreens, or both. Where winter storms are common, the windbreak should be wide and the plants spaced so the windbreak traps most of the snow. This will provide wildlife cover in the trees and shrubs on the leeward side, where little snow blows through or accumulates.



A diagram of a windbreak to protect a feedlot from wind and snow

Certain shrubs and trees are better than others for wildlife. Low-branching evergreens are excellent. So, too, are autumn-olive, Russian-olive, aromatic sumac or skunkbush, buffaloberry, wild plum, honeysuckle hawthorn, privet, and chokecherry. Others may be hardy and useful in your area. Choose only the trees and shrubs that adapt best to your climate and soil. Hunters like field windbreaks and field hedgerows because they attract birds and other game.

State game department officials, Natural Resources Conservation Service (NRCS) and state forestry specialists working through locally organized soil and water conservation districts, and others are available to help you plan your windbreak to make it attractive to wildlife.

As living snow fences

In snow country, properly located living fences of trees and shrubs parallel to your driveway or to highways help hold the snow on the fields and off the roads. For this reason, many county commissioners and highway departments encourage the planting of trees for snow fences.

Leave at least 125 to 150 feet between the windbreak and the road whether the windbreak is to the north, south, east, or west. Winds blow from every direction sometime during the winter months, so this plan is advisable to keep drifting snow from blocking the road. Furthermore, trees too close to a road may shade it and cause icy conditions. The area between the windbreak and road can be planted to crops or grasses that benefit most from the additional moisture afforded by melting snowdrifts.

A snow fence can be a part of your field windbreak system to protect adjoining fields. In some areas, such as the Red River Valley of North Dakota and Minnesota, living snow fences keep snow and drifting soil out of cropland drainage ditches.

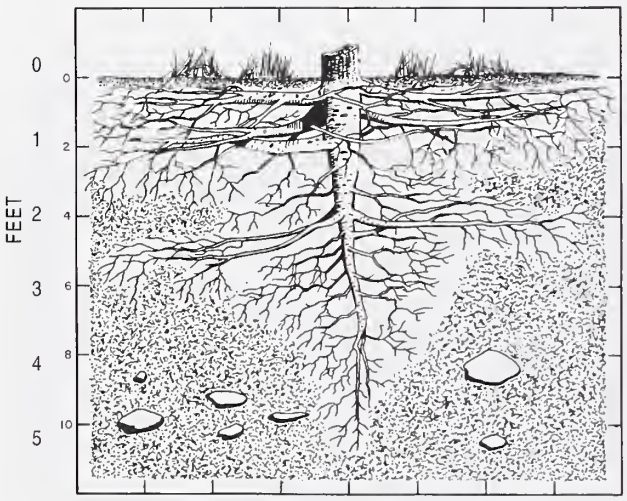
A major feature of living snow fences is the multiple benefits they provide for permanent and high-quality wildlife habitat, environmental beautification, and protection for livestock.

These North Dakota field windbreaks were planted on the contour. The fields in the background were planted to give wildlife food and cover.

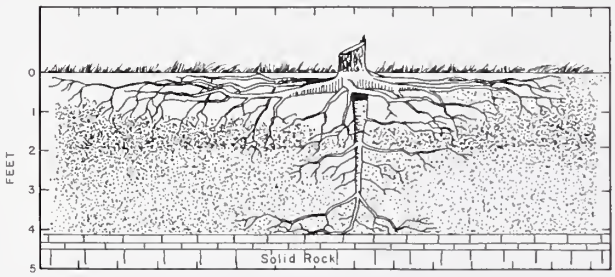
This living snow fence keeps snow off a well-traveled country road.

Soils and Windbreak Growth

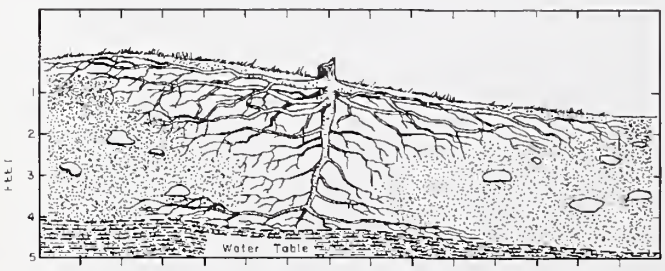
All species of trees and shrubs do not grow at the same rate nor do they grow to the same mature height. Likewise, adapted species vary in their growth on different soils within a geographical area. The amount of available soil moisture during the growing season and soil aeration are two important factors affecting tree growth. These factors are largely determined by soil texture and depth and by climate.



A good loam soil allows moisture penetration and deep, uniform distribution of tree roots.



These tree roots could not grow any deeper because of the solid rock.



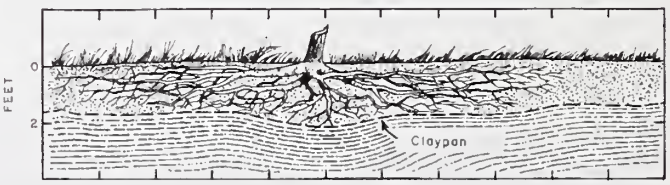
A high water table prevents deep root penetration. These roots stopped at 4 feet. Tree roots must have air to grow.

All species grow well on deep, fertile, well-drained sandy or silt loam soils without hardpans and with adequate available water. These soils allow extensive root penetration and provide all the essentials for good tree growth.

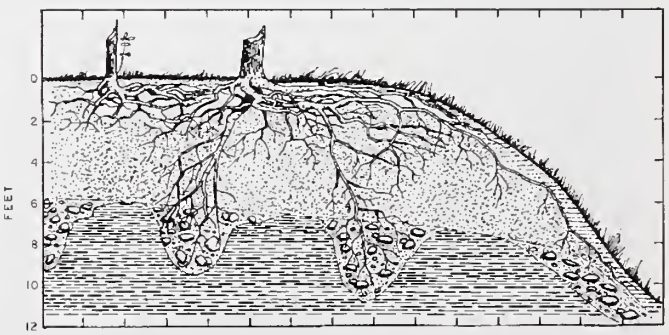
Only a few species of trees can tolerate saline, sodic, or very acid soils. Some trees grow fairly well on shallow soils for a short time, but eventually their growth rate may slow or stop and they may die. Disease problems also multiply on these soils.

Tree growth is only fair to poor on poorly drained clayey soils, which are less porous, have a slower water infiltration rate, and are subject to runoff. These soils can store considerable moisture, but much of it is not available to plants. Aeration is poorer, root systems are shallower, and tillage is more difficult than in sandy or silt loam soils.

Studies of windbreak growth in the Central Plains, following a 5-year drought, showed that all adapted species grew well in a deep sandy loam and in soils that had a stable water table. In 20 years, cottonwood grew to 60 feet; Siberian elm, 50 feet; ash and hackberry, 35 feet; bur oak and Osageorange, 25 feet; and ponderosa



The claypan soil restricted the roots of this tree to 2 feet in depth.



Tree roots follow moist sand and gravel pockets.

This windbreak protects a field of alfalfa in Montana

pine and eastern redcedar, 20 to 25 feet. In adjacent windbreaks on clay soil only Siberian elm, oak, Osageorange, pine, and eastern redcedar survived. Vigor, however, was only fair and growth was about one-third less than that on deep sandy loams. On very sandy soils only pine and eastern redcedar survived and growth was poor.

Since 1951, teams of NRCS soil scientists and foresters have studied soils and windbreaks to determine windbreak growth on different soils. They carefully describe the soils, take measurements of tree height and age, and observe general vigor and condition of the trees. If available, this information is included in published soil surveys. These reports provide information about the soils in different windbreak suitability groups and about the growth that can be expected for different trees on these soils. The information helps determine the kind of trees to plant. The soils are grouped in windbreak suitability groups according to their physical characteristics.

Conservation Tree and Shrub Suitability Groups

Conservation tree and shrub suitability groups have been developed as a guide for selecting species best suited to different kinds of soils, and climate, predicting height growth at 20 years, and measuring effectiveness. They can be used to select plant materials for windbreaks, recreation, and wildlife plantings.

Conservation Tree and Shrub Suitability Group	Description
1	These are excessively well drained to moderately drained soils that receive beneficial moisture from favorable landscape positions, flooding runoff from adjacent land, or they have beneficial seasonal high water table during the spring. Limitations can be a high pH that will have an effect on selection of species for this group. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs.
2	Soils in this group are poorly drained or very poorly drained, excessively wet or ponded during spring or overflow periods. The limitations of this group are the degree of wetness, pH, and poor drainage. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs. Spring planting may be delayed because of wet conditions. Soil blowing is a concern on sandy soils.
3	Soils in this group are deep, well drained, loamy and silty upland soils with moderate and moderately slow permeability. Competition from grass and weeds is the principal concern in establishing and managing trees and shrubs.
4	Soils in this group are moderately deep and deep loamy and clayey upland soils with slow or very slow permeability. High clay content and droughtiness will affect the selection of trees and shrubs.
5	Soils in this group are loamy and sandy and will typically have a moderate to a high available water capacity. Soil blowing and grass and weed competition are the major limitations to establishing and managing windbreaks.

Conservation Tree and Shrub Suitability Group	Description
6	Soils in this group are well drained, loamy, and silty soils that are moderately deep over sand and gravel, bedrock, or other layers that can severely restrict root growth. Droughtiness will affect plant selection on this group. Grass and weed competition will be a limitation. Supplemental watering may be needed for establishment.
7	Soils in this group are deep, excessively drained sandy soils. Droughtiness and soil blowing are the principal concerns. Special attention for site preparation and planting methods is needed to establish a windbreak on these soils. Only conifers are recommended on these soils. Supplemental watering may be essential for successful establishment of a windbreak.
8	Soils in this group are calcareous at or near the surface. They do not receive beneficial moisture from run-in and flooding, nor do they have a seasonal high water table. High calcium content and grass competition are the principal concerns.
9	Soils in this group are affected by saline and/or sodic conditions. Conditions affect establishment, vigor, and growth of trees and shrubs.
10	Soils in this group have one or more characteristics such as soil depth, texture, drainage, channeled phases, droughtiness, slope, or salts which will severely limit planting, survival, and growth. Onsite investigation will be needed to see if a windbreak can be successfully established.

Planning Windbreaks

This farmstead is well protected from wind and snow. The field windbreaks also protect the soil.

A wind barrier of trees and shrubs protects and beautifies this attractive country home.

Windbreaks for your home or farmstead, fields, or livestock shelter should be planned carefully. A single windbreak or a windbreak system is an important part of your complete soil and water conservation plan. This plan, usually made with NRCS or local forester's assistance, records all the necessary conservation practices.

For farmstead and home

The location and layout of your farmstead or country home windbreak should be considered with care, or it may become a liability rather than a asset.

Where drifting snow or blowing soil is a problem, give a lot of thought to where you place your windbreak plantings in relation to the main buildings, yard, and driveways. Because the windbreak will be there for a long time, it pays to locate it correctly in the beginning. A homeowner may need to change the location of fences, driveways, and feedlots to get the most advantage from their windbreak.

Your farmhouse may be too close to the road to allow planting an adequate windbreak. If so, consider planting a windbreak across the road from your house.

Avoid creating blind corners by placing windbreaks too close to highway intersections; they are a safety hazard. In the North, you must plant back far enough to keep snowdrifts from blocking the road. When building a new home remember to leave room for a windbreak.

To gain the most protection from your windbreak, locate it perpendicular to the prevailing winds so that it protects two or three sides of your farmstead. Wind and snow whip around the ends of a windbreak; therefore, the windbreak must extend at least 100 feet beyond the area to be protected. Avoid lanes and roads that pass through the windbreak if possible, especially in snow country. If lanes or roads are necessary, run them at an angle through the windbreak.

Leave 100 to 150 feet between the windbreak and the area to be protected. At this distance you will get adequate protection from winds, and you should not be troubled with drifting snow in the yard. If possible, place the windbreak no more than 300 feet from your home. On sloping land, plant on the contour if practicable. Divert water into the windbreak from an adjoining field or road ditch in low-rainfall areas. Trees will not grow well in areas of old feedlots; therefore, avoid planting there.

If you have an old windbreak or one that is too open at the bottom, it can be improved by planting another row or rows of trees and shrubs on the windward side. A colorful shrub or evergreen row can be added to the leeward side also. Or you may want to plant a whole new windbreak—either to the windward or leeward side, depending on space. When the new windbreak reaches effective height, you can remove the old one or leave it for additional wildlife cover.

Depending on location in the North, a windbreak for a country home should be comprised of five to eight rows in order to give wind protection and trap most of the snow. Species used should give year-round protection, provide a uniformly dense barrier from the ground line to the top, and have a reasonably long life.

In the South and other areas where snowdrifting is not a problem, a single row or more may suffice for a home windbreak. Evergreens (conifers) are always preferred for winter protection. If you want only summer protection, plant a few rows of broadleaf (deciduous) trees to screen the hot winds. A dense windbreak may cause air stagnation and increase temperatures in the yard.

To provide additional screening, shade, or beautification to the farmstead or country home, consider adding rows or clumps of trees and/or shrubs to the primary windbreak.

When selecting plant materials, choose ones with different flower colors, fall foliage colors, textures, and flowering habits to provide visual variety, especially on the inside rows. Planting windbreaks with curves definitely enhances esthetic enjoyment.

A young farmstead windbreak planted on the contour is a pleasing layout and shows good planning.

Forage yields are higher when fields are protected by windbreaks

Caragana windbreaks, spaced five rods apart, protect these Montana fields.

A field windbreak protects soil and crops and helps hold and distribute snow in the field.

For fields

Field windbreaks should be laid out at right angles to prevailing damaging winds. Generally, they consist of one or more rows of trees placed along the windward side of a field with additional parallel windbreaks through the field as needed. The distance between the rows should be about 10 times the height of mature trees.

In some localities damaging winds come from several directions, making isolated, one-directional windbreaks of little value. In this situation, a pattern of windbreaks forming squares or two-directional combinations is needed to provide protection.

The majority of wind velocity reduction by windbreaks occurs for a distance of about 10 times the height of the trees. Thus a windbreak 30 feet high gives protection to a strip about 300 feet wide when the wind direction is at right angles to it. Some protection is provided for a distance of 20 to 25 times the height of the trees. If you know the expected height your trees will grow, you can tell how far apart to place multiple field windbreaks. NRCS uses the expected height of the windbreak at 20 years to determine the spacing between windbreaks. If you want to space the windbreaks farther apart, other factors—soil texture, climate, crop residues, and soil roughness—must be known in order to design an effective wind erosion control system.

Field windbreaks should follow the contour in sloping fields if the slope is generally at right angles to damaging winds. If other structures, such as terraces or an irrigation system are needed, they should be planned and laid out at the same time as the field windbreaks. Because a windbreak generally is placed at right angles to the damaging winds, it may not always be necessary to plant the entire length of a contoured field.

Windbreaks in the right place may keep your irrigation and drainage ditches from filling with windblown soil. Some species, however, may inhibit some underground drainage lines with spreading roots.

Besides keeping in mind windbreaks can create blind corners and become safety hazards, consider present and future underground and overhead utility lines when deciding where to locate your windbreak.

Some alternative measures you can use in combating wind erosion are barriers of annual plants such as rye, corn, sorghum, or sunflowers, and cover crops such as oats or rye. Protection from wind erosion is especially important until a windbreak reaches an effective height.

An increasingly popular alternative is the use of perennial grass barriers. These grass strips should grow to be at least 3-feet tall. Your local NRCS office or district forester has useful information about species adapted to your area.

It would be worthwhile for you to ask the local NRCS conservationist or someone who understands conservation problems to help you plan your wind-erosion control system. After you get all the facts about your soil and the kind of protection needed, you can decide how many field windbreaks are needed and where they should be located.

Effective wind control, crop protection, wildlife habitat, and other benefits require a system of conservation farming. Irrigation systems, such as center pivot irrigation, require careful planning. Crops will benefit if fields are protected by planting trees and shrubs at the corners of the fields, low-growing shrubs or other vegetative barriers across the fields, and tall windbreaks along the edges.

In summary, considerations in planning field windbreaks include climate and wind, soil texture, soil roughness, size of fields, height of mature trees, crop residues left on the surface, kinds of crops to be grown, annual cost of installing and maintaining the protective measures, and the potential monetary returns and other landowner objectives.

For livestock shelter

In range country where winter storms are a hazard, many ranchers plant tree shelters to protect livestock, to trap snow, and to reduce the chilling effects of wintry winds. These types of windbreaks are generally called "outdoor living barns."

Windbreak design for center pivot irrigation requires careful planning.

Caragana windbreaks, spaced five rods apart, protect these Montana fields.

In feedlots protected by windbreaks, cattle eat less and weigh more.

Five to eight rows of trees are needed in the North to protect livestock. Fewer rows may be adequate farther South. The windward row of the windbreak should range from 100 to 200 feet from the livestock area to allow for adequate snow storage. Some rows of evergreens (conifers) are preferred for winter protection. Feed supplies and water should be within the area protected by the windbreak. Plantings are usually made in an L, U, or E design.

Establishing Windbreaks

What kinds of trees and shrubs to plant

Many kinds of evergreen and broadleaf trees and shrubs are suitable for windbreaks. Tall, medium tall, dense, and low-growing trees can be used singly, together, or in combination with shrubs. Some are fast growing and short lived, others grow more slowly and live longer.

Choosing the right species is important. You must consider which species are best suited to your soil, the climate of the area in which you intend to plant them, and the kind of windbreak you want. Your site may have a wet area, a stony knoll, or some other unfavorable condition. If you do not choose species that will grow under the unfavorable condition, you may have gaps or holes in your windbreak. Use species that will give as much height as the soil and available moisture will support when the trees are full grown.

Evergreens, such as spruce, pine, cedar, and juniper, are excellent for windbreaks. They give year-round protection and are usually long lived. Where they grow fairly fast and survival is good, the entire windbreak can be evergreens.

Broadleaf trees, and shrubs, may be used along with evergreens to get protection as early as possible if evergreens grow too slowly or are difficult to get started. Broadleafs usually grow faster and give protection sooner than evergreens but may not live as long.

Some species of trees and shrubs can invade other areas where they interfere with cultivation or other farming operations. For this reason, it is a good idea to consult your local forester or NRCS conservationist for recommendations on the best species to plant.

In this planned community in North Dakota, eight-row windbreaks provide privacy and maximum protection.

Eastern redcedars make an excellent windbreak for this wheat field in Nebraska.

Where to plant

If an evergreen row is to be planted next to a broadleaf row, make sure the broadleafs do not interfere with the growth of the evergreens. Use a slowgrowing broadleaf variety next to the evergreens or leave additional space between the evergreen and broadleaf rows. At maturity, the trees in one row should not overtop or suppress the ones in a neighboring row.

In some parts of the country, evergreen rows are preferred on the leeward side of the windbreak; in others, on the windward side. The deciding factor should be the amount of tree breakage expected from melting snowdrifts or the amount of sunlight each species requires. Shrubs are often used to increase density near the ground line and to help trap snow within the windbreak. It is best to follow the arrangement common in your area.

How to space

Plan for adequate spacing between rows in the windbreak. In areas with adequate moisture, 10 to 15 feet between rows is best; in dry areas as much as 18 feet or more may be needed for optimum growth. Allow enough space between the rows to cultivate with available farm cultivators and lay out the corners of the planting so the equipment can make the turns.

With wide spacing, cultivate for the life of the planting in order to prevent weeds competing for moisture. It is often advisable to keep a strip 8 to 10 feet wide around the outside of the windbreak in clean cultivation as a firebreak.

Regardless of the spacing between windbreak rows—for home or farmstead, livestock, or wildlife plantings—space the plants close enough together within the row to achieve a barrier within ten years. It is advisable to consult your local NRCS conservationist, county extension agent, or local forester for the spacing recommended in your area.

Spacing within the row is determined by the expected crown spread and density of the trees and shrubs at 20 years. A key planning criterion is to allow enough room for the trees to grow without adverse stress.

Rows of annual sunflowers planted as wind barriers protect tomatoes in a California field.

Additional rows of eastern redcedar have been planted to increase effectiveness of the older windbreak on the right.

Grass strips protect cotton seedlings against blowout and soil-particle abrasion.

Hawaii flower growers protect the quality of their flower crops with wind barriers and windbreaks.

How wide and dense

The amount of protection you need will determine in part the number of rows and the density of the windbreak planting. The amount and extent of wind reduction depend on density, width, height, length, cross-sectional shape, and continuity of the windbreak. If you want maximum protection at ground level, plant more shrubs or dense-growing evergreens; if you wish to protect large cultivated fields with as few windbreaks as possible, use tall trees and shrubs; if you want to attract wildlife, plant wide windbreaks of the shrubs and evergreens most favored by wildlife; and if you want windbreaks only to trap snow for road protection, one or two rows of dense low-branching species may do the job in some regions.

In irrigated areas and also where rainfall is favorable, planting one or two rows of trees may be adequate for field windbreaks. On the other hand, where tree establishment is difficult—the Great Plains, for instance—more than two rows may be needed to achieve adequate protection. Even here, however, windbreaks of one or two rows can be effective where soil and rainfall are favorable and other conservation practices are used.

Because field windbreaks generally do not need to reduce wind currents to the same degree as those for the home, windbreaks can be narrower and less dense. Part of the wind currents can blow through the windbreak and still not damage crops or start soil blowing. A windbreak that is partly open near the ground dissipates the wind to a greater distance leeward and helps avoid eddying effects. To be effective, a field windbreak, should be from 40 to 60 percent dense.

In snow country, it is desirable to have a large part of the snow blow through the windbreaks onto the fields. If this is the primary purpose, use a series of one-row windbreaks with trees widely spaced and the windbreaks spaced 10 times the height of the trees (10 H). Since the wide spacing for snow management may not give adequate wind erosion control, additional wind erosion control practices may need to be planned.

Windbreaks for commercial orchards, vineyards, truck gardens, and specialty crops are usually one row. For orchard protection, planting a species that leaves the bottom open or pruning the lower branches to permit air drainage may be desirable to prevent frost pockets from developing. Windbreaks, especially for orchards and vineyards, should be at least one and a half times the height of the crop that is being protected. Planting the windbreak 2 or 3 years before the orchard or vineyard is always suggested.

For farmsteads and country homes, livestock shelter, and wildlife habitat, windbreaks need to be wider and denser than for fields and crops, generally three to eight rows.

How to prepare the land

Always stake out your windbreak before you prepare the land in order to be certain the windbreak will have the right width, length, and location. Good land preparation pays big dividends in increased tree-growth and fewer weeds. Land preparation needs to begin the year before planting. The windbreak plots should be fallowed at least 1 year in dryland areas. Fallowing stores up moisture and helps to control weed growth after planting. If you have the equipment to do the job, leave the stubble on the surface. Sod should be broken and worked thoroughly. Some areas, especially where the sod is heavy, may require 2 years of fallow to kill the sod and control the weeds.

A properly prepared seedbed is the first step in planting a windbreak in this field in Colorado.

Plastic landscape mulch is laid down after planting. Then holes are cut to release the seedlings. This planting method is effective for weed control and water conservation.

Weed control is essential in establishing windbreaks.

Weeds are controlled next to the windbreak on these sandy soils. A corn cover crop is planted between rows to reduce soil blowing.

Where rainfall is adequate and in irrigated areas, deep tillage in the fall is best on loam or silt loam soils. If your planting site has grass or other perennial weeds, treat them with a herbicide and/or tillage before planting the trees. Fallowing or growing a row crop on these sites the year before you plant the trees will help.

It is best to leave some grain stubble or plant a cover crop on cultivated soils that are likely to blow. Do not plow in the fall. Several weeks before tree planting time, till strips wide enough for the tree rows. This gives the soil time to settle. The same applies to sandy grassland where it is not safe to plow up the whole area. Where listing is common, some farmers prefer to plant seedlings in lister rows.

Where moisture is short or where the soil is apt to blow, plant strips of tall growing plants, such as corn, sorghum, or millet. Plant one or two rows the year before you plant the trees and keep them cultivated. These strips will protect the soil against blowing and catch snow during the winter. The snow, as it melts, contributes moisture to the tree seedlings.

How to choose seedlings

Use seedlings which have been grown in a nursery in your area or from a nursery having a similar climate. State or private nurseries in your own state generally can provide the best seedlings for your windbreak. Your county extension agent, local forester, NRCS conservationist, or local conservation district staff can help you contact a suitable nursery. Ordering extra seedlings with your first order so that you have them at hand to replace dead ones the following season is a good practice. These extra seedlings should be planted in an adjoining area at the same time the windbreak is planted. They can then be transplanted the following year to replace dead ones.

Seedlings should be of good quality. The added cost for quality will be small compared with the total cost of a windbreak.

Choose the size carefully because seedlings that are either too small or too large generally don't grow well. Seedlings of broadleafs should be about 18 to 36 inches in stem length. These are 1- or 2-year-old seedlings. They should measure about 3/16 to 3/8 of an inch about 1 inch above the root collar. The root system should be well branched, from 8 to 9 inches in length, and in balance with the stem. Larger seedlings cost more and ordinarily do not do as well as the 18- to 36-inch ones.

Evergreen seedlings should be 8 to 12 inches high and have a well-balanced and fibrous root system. Purchase the grade and age recommended for your area.

Evergreen survival in dry, windy areas is often poor. Drying winds and hot temperatures kill or severely damage the stems before the root system can start working. Some nurseries offer containerized evergreen seedlings at a reasonable cost. Although the cost is higher than for bare-rooted seedlings, these seedlings can have a much better survival rate.

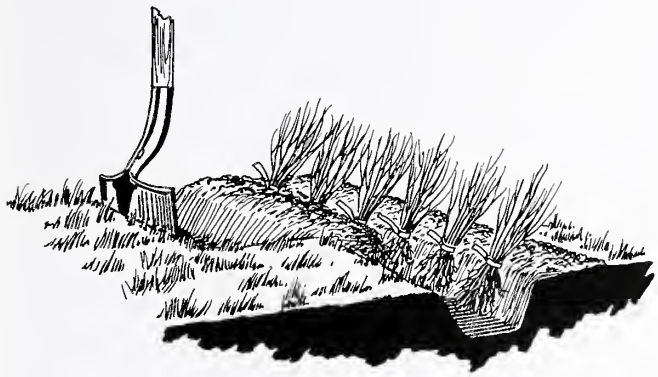
How to plant seedlings

When the seedlings arrive, open the nursery bales and check the plants for heating, molding, or dryness. If they are satisfactory, store them in a cool, shady place with roots protected, and plant within a few days.

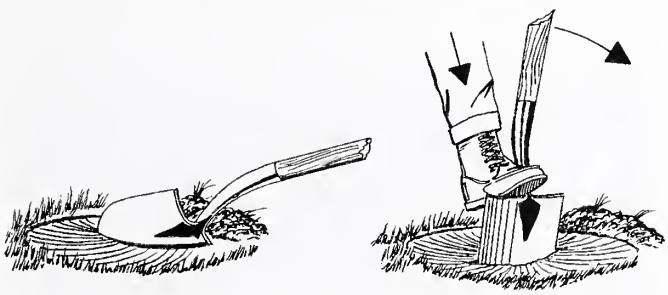
If the seedlings cannot be planted immediately, dig a trench about a foot deep and bury the seedling roots in soil with the tops exposed. This is called "heeling-in."

Pack the soil firmly, water thoroughly, and make certain all roots are covered. The seedlings may be stored in a cooler as long as the plants are still dormant.

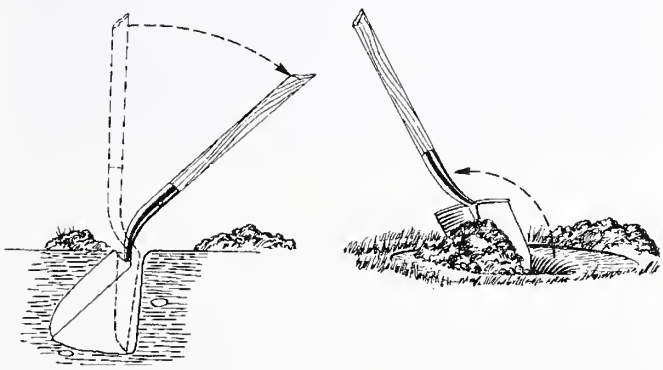
Evergreens require extreme care. Do not expose the roots to the air for more than a few seconds. When heeling-in evergreens, split the small bundles and spread out the seedlings in a trench to make sure the root system of each seedling is protected by soil.



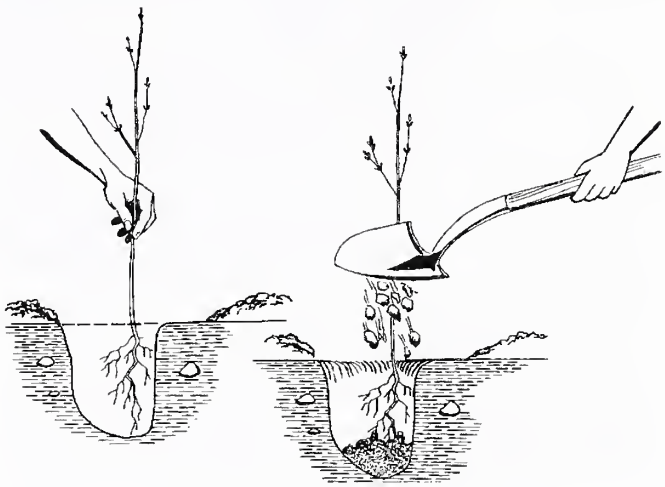
Heeling-in bed.



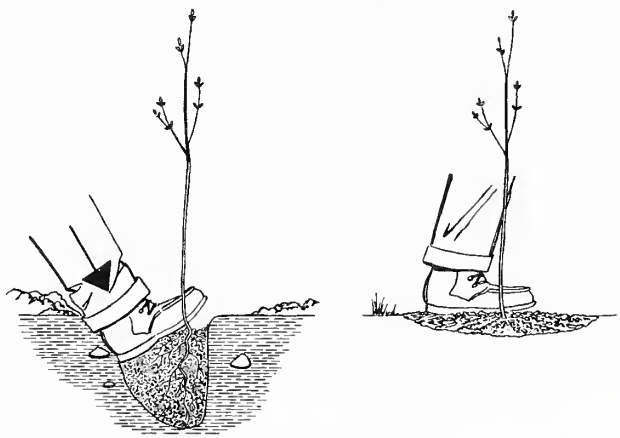
Scrape dry soil from surface. Reverse shovel and push into soil.



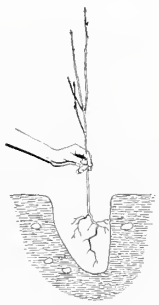
Push handle ahead. Scrape soil back to enlarge hole.



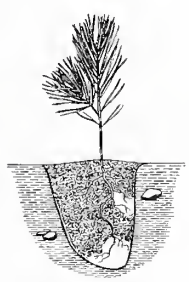
Place seedling in hole and fill in.



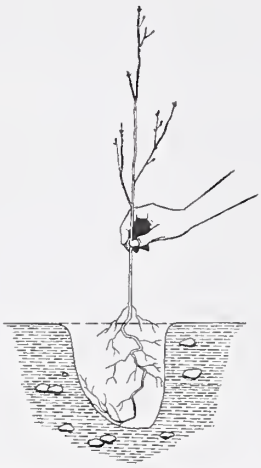
Pack down tightly



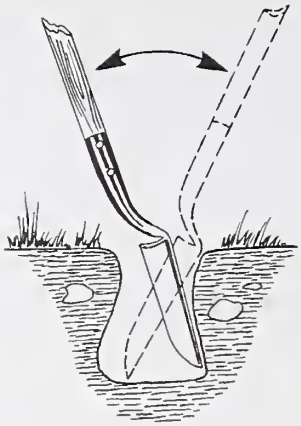
Good hole—tree too deep.



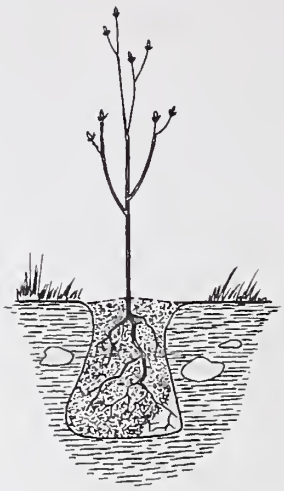
Good hole—air space at bottom because of poor packing.



Shallow hole, root collar above ground line, roots not in normal position



"K"-type hole resulted from pumping shovel handle.



Tree planted in "K" hole, air space in bottom of hole.

Plant the seedlings at the best time for your locality. Most planting is done in the spring after the danger of frost has passed and the soil is warming. It is best to get your seedlings at planting time.

Many soil conservation districts and some State forestry or game departments provide mechanical tree planters. Trained planting crews are often available locally.

If you hand plant, stake out the rows according to your plan. Planting the trees in straight rows or on the contour will make cultivating easier.

A good planting job ensures better survival. Avoid planting hot, windy days. After the windbreak is planted, water if the weather turns hot and windy. Shingles or burlap strips staked on the windward side to shade and protect the evergreens will increase survival.

Replace dead trees and shrubs with seedlings of the same species the year following your initial planting. A gap in your windbreak is like a hole in a fence. In some areas, extra trees will be planted so they can be used as replacements.

Planning for supplemental water

In the arid and semiarid regions of the United States, supplemental water will be necessary to successfully establish windbreaks. This extra water may be needed only to establish the trees and shrubs; however, permanent irrigation may be needed in the arid regions. Drip irrigation systems have proved to be an effective method of applying needed water to the plants. Technical assistance can be obtained from NRCS to design a system to fit your needs.

Water harvesting methods, such as land-shaping, snow management, the use of plastic mulches, or landscape fabrics, have been effective in conserving and fully utilizing available water for the plants.

Managing Windbreaks

The trees have a benefit of all the moisture in a weed-free windbreak.

Supplemental water is needed to establish windbreaks in many parts of the arid west.

Windbreak establishment does not end once the seedlings are in the ground. After the windbreaks are planted, care should be taken to protect them from weed competition, fire, insects, diseases, and livestock. Replant spot or row failures the second and third seasons. Gaps concentrate the force of the wind causing more problems than in unprotected areas.

On grassland soils, in the Great Plains for instance, it is necessary to tend trees as you would field crops. They must be cultivated, weeds and grass kept out, insects and diseases controlled, and water conserved or diverted for their use. Controlling competing grass is essential for a successful planting.

Trees change in character as time passes. Some species thicken up, others thin out, and still others may lose their lower branches. It may be necessary to thin some rows to keep the number of trees in balance with the available moisture. Some cutting and pruning may be needed to keep an adjacent broadleaf row from damaging evergreens. In windbreaks overrun with weeds and grass, vigor may be restored by removing partial row failures, controlling the grass and weeds, and replanting. For optimum growth and long life, windbreak trees require the best care you can give them.

Many windbreaks that protect orchards and vineyards are kept under a regular management schedule. The goal is to prune, generally by mechanical means, to keep the windbreak crowns as narrow as possible and at a desired height.

Protecting from livestock

Livestock must be kept out of windbreaks. This is true regardless of the age of the trees. Livestock browse the leaves, break off branches, compact the soil, and reduce the lower density of the windbreak. Weeds and grass creep into the openings, and the windbreak becomes less effective. Second only to fire, an invasion of livestock is the surest way to ruin a windbreak.

When the windbreak is young, poultry should also be kept out. They eat the tender buds.

If you need a fence to keep livestock out, do not crowd it in too close to the trees. Allow ample feeding space for the tree roots and room for cultivating. A shallow (1 to 3 inches) cultivated strip next to the windbreak serves as a firebreak, keeps grass and weeds from creeping in, and lets the soil take in water more readily.

Controlling weeds and grass

After planting, no single management practice is more important than the control of competing weeds and grass. Competition for moisture and nutrients reduces growth and vigor, and may cause a complete planting failure. Even where there is plenty of moisture, trees and shrubs do better if weeds and grass are controlled.

When cultivation is used, shallow cultivation is best (1 to 3 inches deep). You may damage roots if you cultivate deeper. A sweep-type cultivator, spring-tooth harrow, or a tandem disk can be used to kill weeds between tree rows. A variety of in-the-row cultivators are available for young weed seedling control within the planted rows. Some hand-hoeing may be needed. Try to keep the land level and do not ridge the rows. Leave the surface in a rough condition for erosion control and moisture absorption.

Cultivate for as many years as you can—until the tree canopy closes. In dry areas, or on unfavorable soil, cultivate for the life of the windbreak. Keep an outside strip next to the windbreak clean. This will make the trees grow faster and live longer.

In the North, cultivate a last time during late summer. If the windbreak area is likely to blow in the winter, leave some late summer weeds or plant a cover crop between the tree rows early enough to make fair growth before winter. This will protect the seedlings and help trap snow for additional moisture.

Pre-emergent herbicides control annual weeds and grasses easily and cheaply when applied according to manufacturers' directions. Caution must be used, however, because some plant species are more sensitive to herbicides than others. You can apply herbicides with mechanical spray rigs or with a backpack sprayer, for small plantings. Adjust the nozzle height to spray a 15- to 20-inch swath on each side of the tree row. It is best to confine chemicals to the tree row and cultivate the area between the rows.

Information about the kinds of herbicides to use and the times and rates for spraying are available from your county extension agent, local forester, or NRCS conservationist.

Mulching

Plastic mulches and landscape fabrics are being used throughout the United States for water conservation and weed control with windbreak plantings. They are used for windbreaks where cultivation may be difficult to accomplish. They are also used to conserve soil moisture for plantings in arid and semiarid regions.

Where water erosion is a problem in the windbreak, spread a light organic mulch once a year as long as it is needed. Consult your local NRCS conservationist if water erosion is severe.

Mulching with hay or straw in place of cultivation is unsatisfactory in areas of dryland farming because the hay and straw tend to blow away.

Irrigating

Irrigate windbreaks much the same as you do deep-rooted farm crops. One good soaking is better than several light irrigations. If irrigation water is available after the leaves drop, give the windbreak a soaking just before the ground freezes. A good soaking is especially helpful to evergreens. In the North, however, stop watering about a month before the first frost to give the trees a chance to harden off before freezeup.

Protecting from fire, animals, and herbicide drift

For protection against fire in the windbreak, keep a strip around the windbreak free of weeds and grass.

Rabbits, deer, and mice often damage young seedlings, especially during winter. Several good rabbit repellents and mouse poisons are available from seed houses and nursery stores. Reduce rodent damage by keeping out weeds and grass. Protective plastic tubings can also be used to protect young plants from browse damage from deer and rabbits.

Many windbreaks are damaged by herbicides applied in adjoining fields, although the damage is mistaken many times as that caused by disease or insects. Do not spray during windy periods to avoid the risk of drift, and use nonvolatile chemicals—sprays like 2,4-D often damage trees and shrubs.

Moisture competition and shading

Windbreaks need moisture to live. In dry seasons, tree roots can compete for moisture from the crops planted next to them. This problem is most common in the Southern Plains.

Many farmers plant an early maturing grain crop next to their windbreaks to avoid having the tree roots use moisture needed by late-maturing crops during the hot, dry months. Some farmers plant grass instead of grain. Others use the land next to the trees as a turnaround, roadway, or lane.

Moisture competition is not a serious problem when snowdrifts add moisture. Crops could be planted right up to the tree barrier on this farm.

Root pruning with a ripper or chisel to about 30 inches in depth while the trees are dormant also helps. It is best not to do this when the soil is dry, because the trees may be severely injured. Root-pruning will give better results if it is started when the trees have aged from 4 to 6 years.

If the windbreak casts a shadow, plant a shade-tolerant crop next to it. Use trees and shrubs that will compete the least with adjoining field crops.

Windbreak renovation

When you plant a windbreak, consider planning for the future renovation of the windbreak to maintain its health and effectiveness. A good maintenance program will add to the windbreak's longevity and delay the need for renovation measures.

A periodic inspection of your windbreak will reveal any decline. Contact NRCS or a local forester for help in determining renovation measures that might be required.

Allowing grass to grow around the windbreak stresses trees and shrubs and severely restricts growth. Removing grass or sod is an effective method of renovation.

Row removal and replacement is another renovation technique. It involves the complete removal of dead, dying, or diseased trees or shrubs and replacing them with new plants.

Multiple-row windbreaks may need thinning or a release cutting after 7 to 10 years in order to maintain good growth and vigor. Rate of growth, spacing, and related factors determine the need. It is advisable to contact a local forester or NRCS conservationist for advice before thinning.

Expansion plantings are the most commonly used method of windbreak renovation. This method is used to improve the mid- to low-level density of a windbreak by planting additional rows of trees and shrubs to the leeward or windward side.

Existing fence rows of trees and shrubs offer an excellent opportunity to create a windbreak in a short time by managing what is already growing. NRCS technicians or a local forester can help develop a renovation plan to your liking.

The wind-erosion control and many other benefits offered by a renovated windbreak will ensure continued protection of your resources.

Where Is Help Available?

Before planting a windbreak, get advice from local specialists. Your NRCS conservationist can help you with your soil and water conservation plan, which should include your windbreak system. The county extension agent, the local forester, conservation district staff, and game department officials in some States are also available to help. They can help you design, implement, and monitor your new windbreak and can advise you of any financial help that is available on a conservation cost-sharing basis. In many counties, soil conservation districts rent mechanical tree planters at a reasonable cost or provide total tree-planting services.

Common and Scientific Names of Some Trees and Shrubs Used for Windbreaks

Pacific Northwest

caragana	*Caragana arborescens*
Douglas-fir	*Pseudotsuga menziesii*
Elm, Siberian	*Ulmus pumila*
hemlock, western.	*Tsuga heterophylla*
honeylocust, thornless	*Gleditsia triacanthos var. inermis*
incense-cedar	*Libocedrus decurrens*
juniper, Rocky Mountain	*Juniperus scopulorum*
lilac, common	*Syringa vulgaris*
locust, black	*Robinia pseudoacacia*
pine, ponderosa	*Pinus ponderosa*
pine, Scotch	*Pinus sylvestris*
poplars	*Populus spp.*
redcedar, western	*Thuja plicata*
spruce, blue	*Picea pungens*
spruce, Norway	*Picea abies*
waxmyrtle, Pacific	*Myrica californica*
willows	*Salix spp.*

Pacific Southwest

acacia	*Acacia spp.*
ash, green	*Fraxinus pennsylvanica*
athel tamarisk	*Tamarix aphylla*
buckthorn, Italian	*Rhamnus alternus*
casuarina	*Casuarina spp.*
cypress, Arizona	*Cupressus arizonica*
eucalyptus	*Eucalyptus spp.*
incense-cedar	*Libocedrus decurrens*
locust, black	*Robinia pseudoacacia*
mulberry, fruitless	*Morus alba*
oleander	*Nerium oleander*
pine, Austrian	*Pinus nigra*
pine, Eldarica	*Pinus eldarica*
pine, ponderosa	*Pinus ponderosa*
pomegranate	*Punica granatum*
poplars	*Populus spp.*
quailbush	*Atriplex lentiformis*
saltbush, four-wing	*Atriplex canescens*

Southern Plains

arborvitae, oriental	*Thuja orientalis*
ash, green	*Fraxinus pennsylvanica*
cypress, Arizona	*Cupressus arizonica*
elm, Chinese	*Ulmus parvifolia*
elm, Siberian	*Ulmus pumila*
hackberry	*Celtis occidentalis*
honeylocust, thornless	*Gleditsia triacanthos var. inermis*
juniper, Rocky Mountain	*Juniperus scopulorum*
lilac, common	*Syringa vulgaris*
mulberry, Russian	*Morus alba 'tatarica'*
oak, bur	*Quercus macrocarpa*
pine, Austrian	*Pinus nigra*
pine, loblolly	*Pinus taeda*
pine, ponderosa	*Pinus ponderosa*
pine, shortleaf	*Pinus echinata*
plum, American	*Prunus americana*
plum, Chickasaw	*Prunus angustifolia*
poplars	*Populus spp.*
redcedar, eastern	*Juniperus virginiana*
sumac, aromatic	*Rhus aromatica*
sycamore, American	*Platanus occidentalis*
willows	*Salix spp.*

Northern Plains

ash, green ..... *Fraxinus pennsylvanica*
boxelder ..... *Acer negundo*
buffaloberry, silver ..... *Shepherdia argentea*
caragana ..... *Caragana arborescens*
chokecherry, common ..... *Prunus virginiana*
cotoneaster, European ..... *Cotoneaster intergerrimus*
crabapple, Manchurian ..... *Malus baccata var. mandshurica*
crabapple, Siberian ..... *Malus baccata*
elm, Siberian ..... *Ulmus pumila*
hackberry ..... *Celtis occidentalis*
hawthorns ..... *Crataegus spp.*
honeysuckle, Amur ..... *Lonicera maackii*
juniper, Rocky Mountain ..... *Juniperus scopulorum*
lilac, common ..... *Syringa vulgaris*
oak, bur ..... *Quercus macrocarpa*
pine, ponderosa ..... *Pinus ponderosa*
plum, American ..... *Prunus americana*
poplars ..... *Populus spp.*
redcedar, eastern ..... *Junlperus vlrginiana*
Russian-olive ..... *Elaeagnus angustifolia*
spruce, blue ..... *Picea pungens*
spruce, white ..... *Picea glauca*
willows ..... *Salix spp.*

North Central States

ash, green ..... *Fraxinus pennsylvanica*
cedar, northern white ..... *Thuja occidentalis*
cotoneaster, European ..... *Cotoneaster intergerrimus*
crabapple, Manchurian ..... *Malus baccata var mandshurica*
dogwood, silky ..... *Cornus amomum*
elm, Siberian ..... *Ulmus pumila*
hackberry ..... *Celtis occidentalis*
honeysuckle, Amur ..... *Lonicera maackii*
maple, Amur ..... *Acer ginnala*
maple, red ..... *Acer rubrum*
oaks ..... *Quercus spp.*
pine, red ..... *Pinus resinosa*
pine, Scotch. ..... *Pinus sylvestris*
pine, eastern white ..... *Pinus strobus*
poplars ..... *Populus spp.*
privet, Amur ..... *Ligustrum amurense*
privet, California ..... *Ligustrum ovalifolium*
redcedar, eastern ..... *Juniperus virginiana*
spruce, Norway ..... *Picea abies*
spruce, white ..... *Picea glauca*
willows ..... *Salix spp.*

Southeast and Gulf Coast

arborvitae, oriental ..... *Thuja orientalis*
bayberry, southern ..... *Myrica cerifera*
casuarina ..... *Casuarina spp.*
firethorn ..... *Pyracantha spp.*
honeysuckle, Amur ..... *Lonicera maackii*
laurel cherry, Carolina ..... *Prunus caroliniana*
photinia ..... *Photinia spp.*
pine, loblolly ..... *Pinus taeda*
pine, shortleaf ..... *Pinus echinata*
pine, slash ..... *Pinus elliottii*
pine, Virginia ..... *Pinus virginiana*
poplars ..... *Populus spp.*
privet ..... *Ligustrum spp.*
redcedar, eastern ..... *Juniperus virginiana*

Northeast

alder, European black ..... *Alnus glutinosa*
cedar, northern white ..... *Thuja occidentalis*
crabapple, Manchurian ..... *Malus baccata var mandshurica*
crabapple, Siberian ..... *Malus baccata*
honeylocust, thornless ..... *Gleditsia triacanthos inermis*
honeysuckle, Amur ..... *Lonicera maackii*
larch ..... *Larix spp.*
locust, black ..... *Robinia pseudoacacia*
pine, red ..... *Pinus resinosa*
pine, Scotch ..... *Pinus sylvestris*
pine, eastern white ..... *Pinus strobus*
poplars ..... *Populus spp.*
privet, Amur ..... *Ligustrum amurense*
privet, California ..... *Ligustrum ovalifolium*
redcedar, eastern ..... *Juniperus virginiana*
spruce, black ..... *Picea mariana*
spruce, Norway ..... *Picea abies*
spruce, white ..... *Picea glauca*
willow, purpleosier ..... *Salix purpurea*

These species of trees and shrubs are generally adapted to the whole area but may not be adapted to certain conditions within the region. Check locally to see what plants are adapted to your area. When making plant selections, you should inquire about improved cultivars that may have been developed specifically for your area.